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(54) Coolant system for high-temperature battery for electrically powered vehicles comprises parallel hollow plates through which coolant flows

(57) In high-temperature battery for the power supply of electrically powered vehicles, having a thermally insulating housing 2 and a cooling system with a cooling body 6 which is arranged inside the thermally insulating housing for cooling cells 5, through which body air flows and which penetrates the thermally insulating wall of the housing 2 solely by means of air inlet 3 and air outlet (4 Fig. 2b) connecting elements arranged on it, to achieve better cooling action, the cooling body 6 is formed by a parallel arrangement of plate-shaped cooling-body elements 7 through which air flows and which are designed as hollow bodies, the bar-shaped battery cells 5 being arranged in the space between the cooling-body elements, and an inlet funnel 8 which widens downstream in breadth distributes coolant over the inlet openings of all the cooling body elements 7 and an outlet funnel (14 Fig. 2b) which narrows downstream in breadth collects coolant flowing out of the outlet openings of all the cooling body elements. Baffle plates may be arranged inside each cooling body element.

Fig. 2a

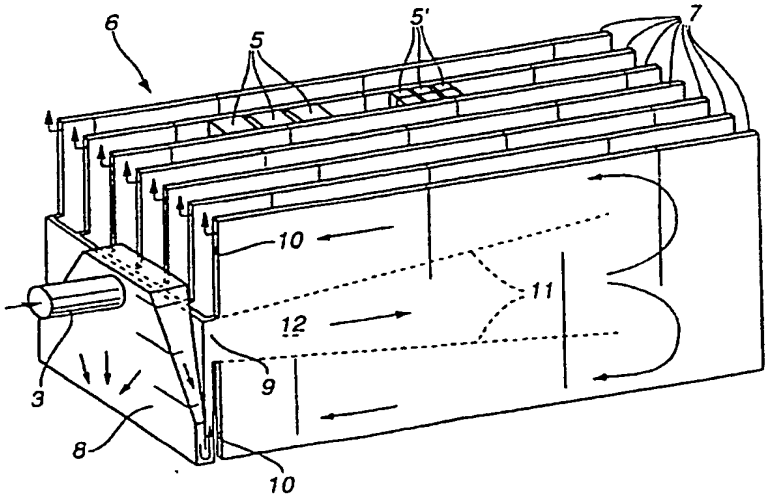

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Fig. 1

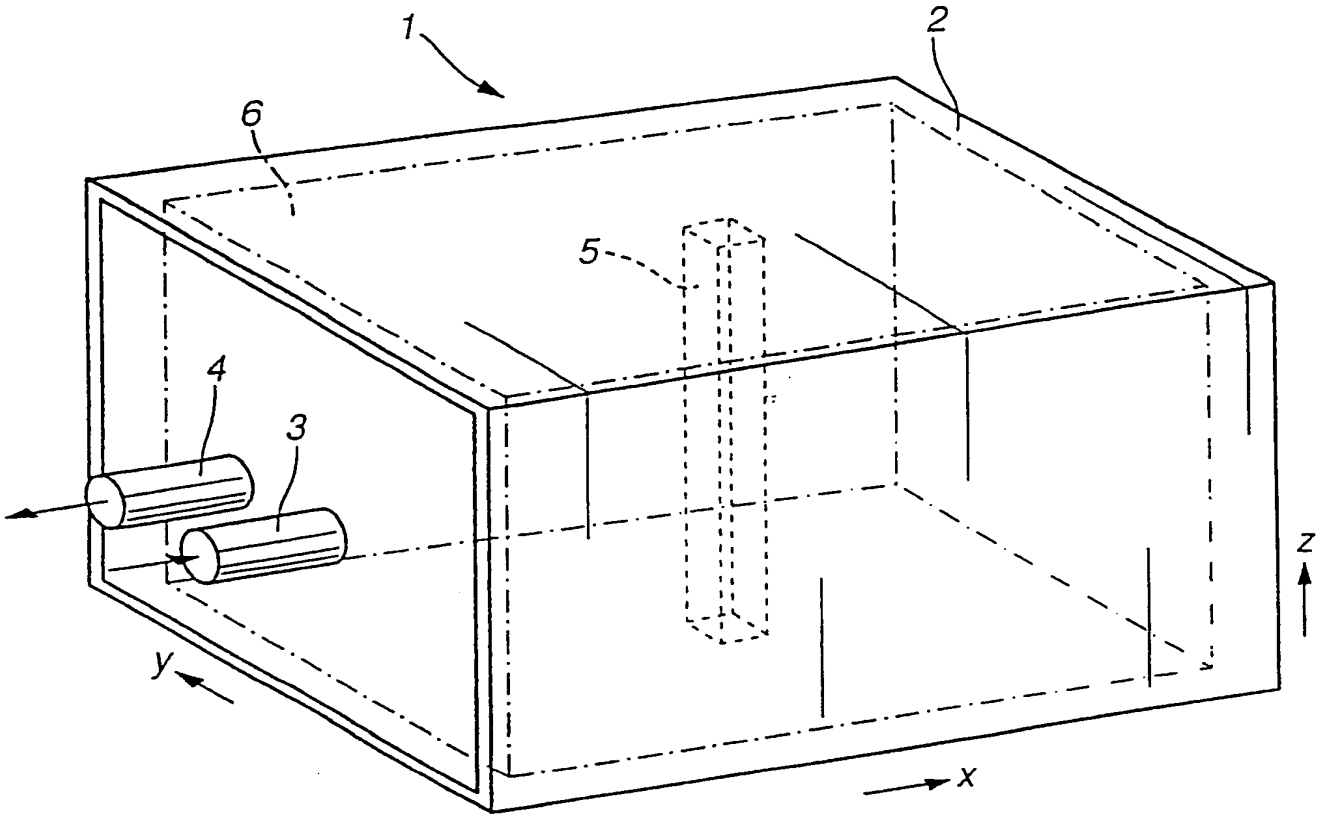


Fig. 2a

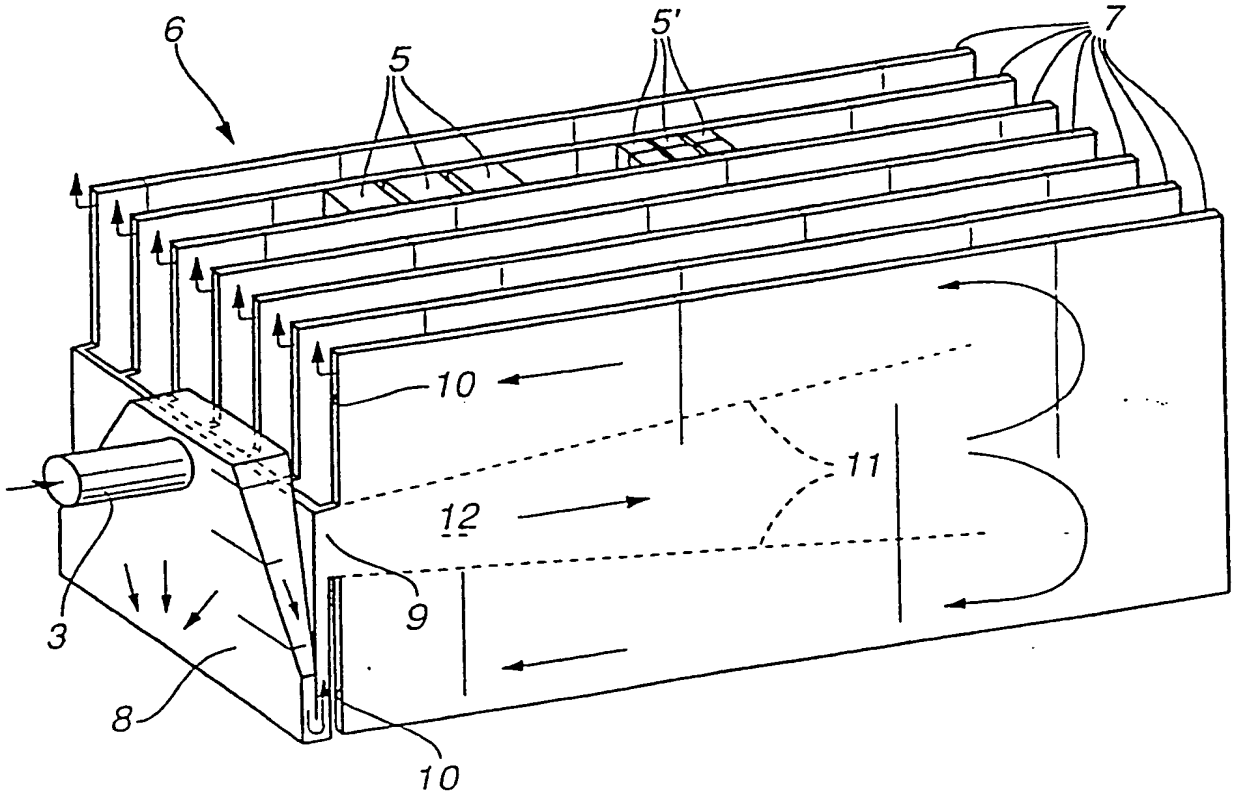


Fig. 2b

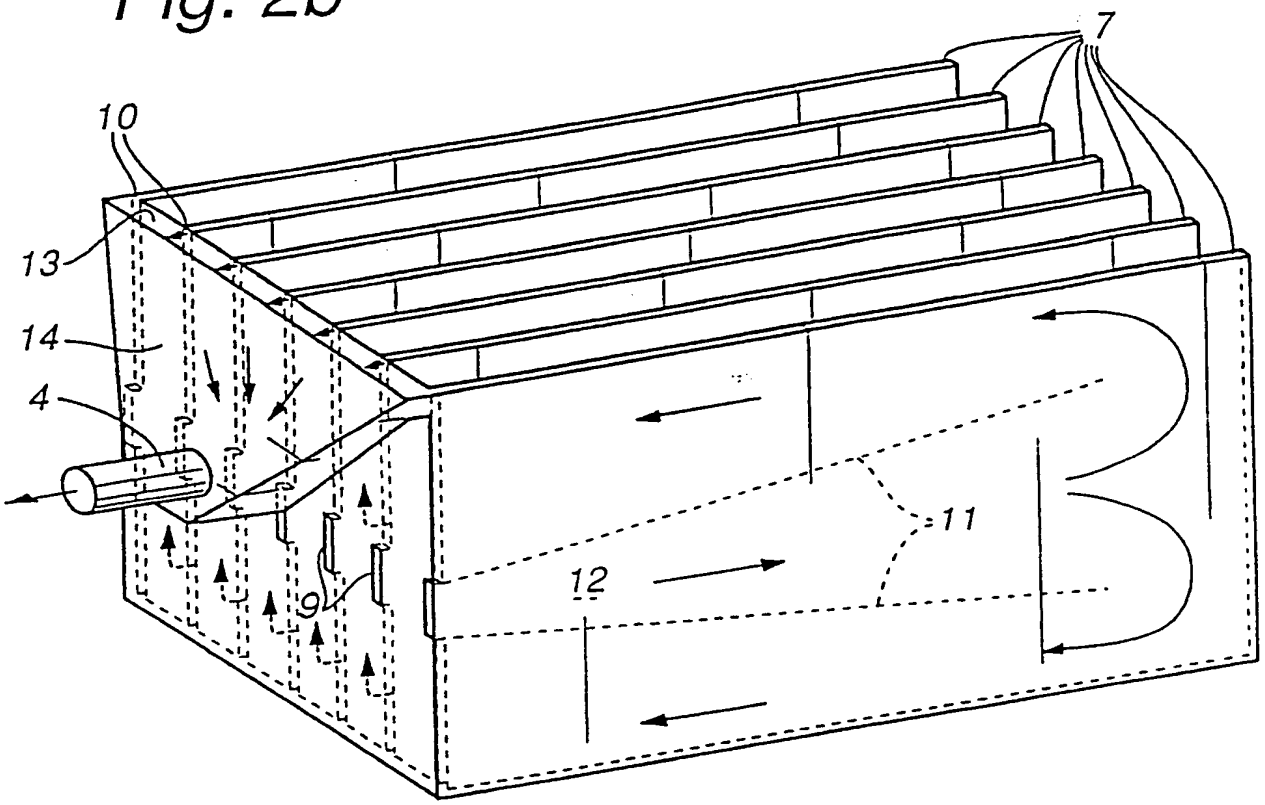
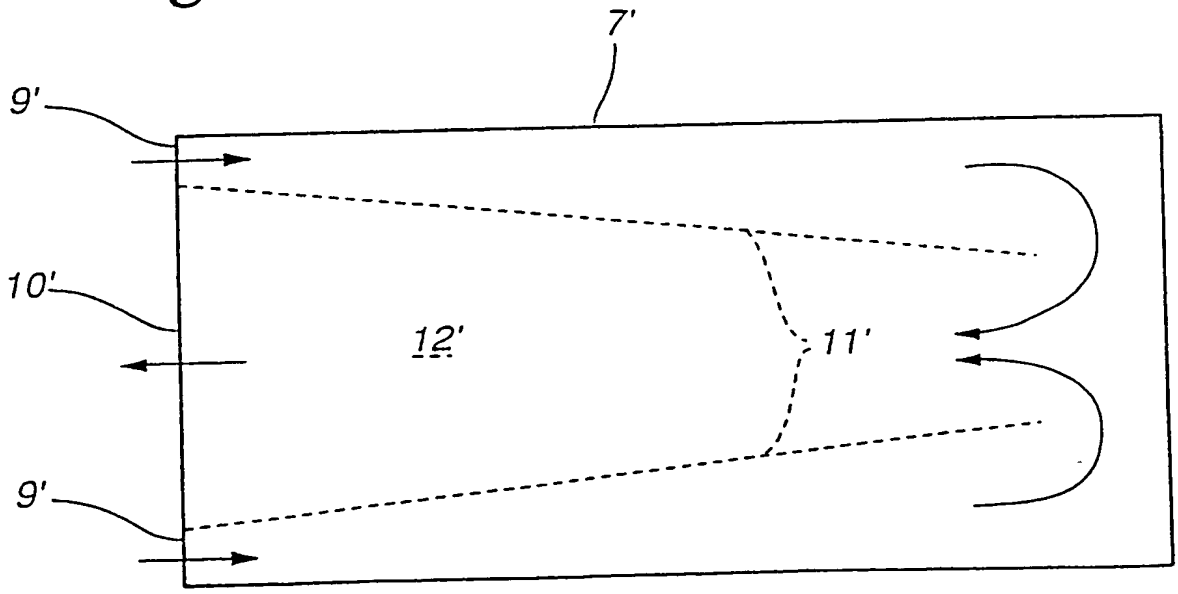


Fig. 3



High-temperature battery

The invention relates to a high-temperature battery for the power supply of electrically powered vehicles, having a thermally insulating housing and a cooling system with a cooling body which is arranged inside the housing, and through which a coolant flows, which penetrates the thermally insulating wall of the housing by means of inlet and outlet connecting elements.

For a sodium nickel chloride battery system, it is necessary to keep to a tightly limited temperature window of, for example, 280-350°C, since, on the one hand, the battery cells should not be overheated during charging but, on the other hand, the cell temperature should not fall below a lower limit value, or else the battery loses efficiency.

In Patent Application P 43 09 621.2-16, previous to but not published before the priority date of the present application, a cooling system is described for limiting the operating temperature when charging the battery and when drawing current. A cooling body through which air flows is provided to remove heat from the battery, which cooling body penetrates the thermally insulating battery housing via an air inlet and an air outlet connecting element. The cooling body is constructed flat in the shape of a plate and is arranged on the upper side or lower side of the housing.

Cooling designs in which only the upper or lower side of the battery is cooled have the disadvantage that, because of the poor thermal conductivity of the battery cells and their large overall height a highly unfavourable temperature stratification results and it is difficult to keep to the abovementioned temperature window. It can thus occur that, on the cooled side, the cell temperature may possibly be already too low, while excessively high temperatures are established on the opposite side. Furthermore, such a cooling design has a very slow response because of the thermal inertia of the battery cells in

combination with their bar-shaped construction (high in comparison to small cross-sections), since the cooling power must act over the entire height of the battery cells in order to be capable of cooling the other end of the cell as well. This cooling design is therefore unsuitable, in particular when it is desired to achieve cooling on demand, that is to say only in the case of possible overheating, as opposed to continuous cooling, since the system does not provide effective cooling response sufficiently quickly.

A high-temperature battery is known from DE 32 42 901 A1, the cooling system of which is particularly suited for bar-shaped battery cells. Because of the large-area cooling along the side surfaces of the battery cells, a substantially homogeneous temperature distribution within the cells and a comparatively fast response behaviour of the cooling are achieved. The counterflow principle is advantageously applied inside the cooling-body elements, as a result of which a cooling power homogeneously distributed over the effective cooling surface of the cooling-body elements is achieved.

The present invention seeks to develop a high-temperature battery such that the cooling action of the cooling system for high temperature is further improved.

According to the present invention there is provided a high-temperature battery for the power supply of electrically powered vehicles, having a thermally insulating housing and a cooling system with a cooling body which is arranged inside the housing, and through which a coolant flows, which

- penetrates the thermally insulating wall of the housing by means of inlet and outlet connecting elements, and
- is formed by a parallel arrangement of plate-shaped cooling-body elements comprising hollow bodies and through which the coolant flows, the battery cells to be cooled being arranged in the space between the parallel cooling body elements, wherein

each cooling body element has, on a narrow side facing the

inlet and outlet connecting elements, at least one inlet opening and at least one outlet opening, an inlet funnel or funnels which widen(s) downstream in the breadth direction, distributing the coolant over the inlet openings of all the cooling-body elements and an outlet funnel or funnels which narrow(s) downstream in the breadth direction collecting the coolant flowing out of the outlet openings of all the cooling-body elements and feeding it to the outlet connecting element.

The improvement of the cooling action, related to the coolant throughput, is achieved in that the airstream through the cooling body is optimized by reducing turbulence and flow detachment.

Advantages of the invention over the prior art consist in that, because of the large-area cooling along the side surfaces of the battery cells, a substantially homogeneous temperature distribution within the cells and a comparatively fast response behaviour of the cooling are achieved. In a particular embodiment, the counterflow principle is advantageously applied inside the cooling-body elements, as a result of which a cooling power homogeneously distributed over the effective cooling surface of the cooling-body elements is achieved. Furthermore, by virtue of preferred embodiments according to the invention, various measures are taken in order to optimize the airstream through the cooling body by reducing turbulence and flow detachment.

The invention will now be described with the aid of exemplary embodiments illustrated in the drawings and described in more detail hereinbelow.

Figure 1 shows an overall view of the high-temperature battery,

Figure 2a shows a perspective view of the cooling body according to the invention (without an outlet funnel),

Figure 2b shows a complementary perspective view of the cooling body according to the invention (without

an inlet funnel),

Figure 3 shows another embodiment of a cooling-body element.

The high-temperature battery represented in Figure 1, which may be constructed on the basis of sodium nickel chloride cells, has a thermally insulating housing 2 for reducing heat losses. The insulation is generally achieved by vacuum insulation. There is a relatively large number of tightly packed bar-shaped battery cells 5 inside the housing 2, for example 13 in the y direction and 17 in the x direction, only one of which is represented as an example. A cooling body 6 according to the invention is located inside the housing 2 and is in thermal contact with the battery cells 5. In this case cold air is fed from outside through an air inlet connecting element 3 to the cooling body 6 and discharged through a corresponding air outlet connecting element 4. The air inlet and air outlet connecting elements 3, 4 have a circular cross-section and penetrate the insulating housing 2. After having passed through the cooling body 6, the heated air can be used, by means of a heat exchanger, for air-conditioning of the passenger compartment.

The cooling body according to the invention and the air guidance therethrough, illustrated by means of arrows, can be seen in Figures 2a and 2b.

Figure 2a shows the cooling body 6 according to the invention, the air outlet connecting element and a corresponding outlet funnel, which collects the air flowing out, not being shown for the sake of clarity. The cooling body 6 consists of a parallel arrangement of plate-shaped cooling-body elements 7 between which, depending on the embodiment, there is one row of battery cells 5 or a double row 5′. As a result, the battery cells 5, 5′ are cooled along at least one side face over a large area.

A particularly configured inlet funnel 8 serves for feeding forward the cold air from the air inlet connecting element 3 to the cooling-body elements 7 and for the

greatest possible uniformity of the air inlet stream; the cross-sectional areas of the funnel 8 crossed instantaneously downwards are substantially constant along the path. Loss-inducing flow detachments are advantageously avoided thereby and a homogeneous distribution of the airstream in the breadth direction y is achieved.

The constant cross-sections are achieved in that the thickness (x direction) of the inlet funnel 8 narrows downwards, whereas its width (y direction) widens to the full breadth of the cooling body 6. Each cooling-body element 7 has, on its side facing the air inlet connecting element 3, a centrally arranged inlet opening 9 and two outer outlet openings 10. The inlet opening 9, through which the cold air passes into the cooling-body element 7, which is designed as a hollow body, has a substantially smaller cross-section than the outlet openings 10. This advantageously prevents the cold air, because of an excessively large available cooling surface area, being heated so strongly on the forward path through the air duct 12, which is designed as a diffuser, that no more cooling power is produced on the return path through the cooling-body element 7.

In order to achieve a diffuser action which is as optimum as possible, that is to say a homogeneous distribution and flow of the cooling air through the cooling-body elements, a plurality of air baffle plates 11 are arranged inside the cooling-body element. These form an air duct 12 which widens in the throughflow direction. The cooling air is divided at the end of the air duct 12 and, after diversion, is fed in each case to an outlet opening 10. Other arrangements of air baffle plates are, however, also conceivable, for example as they are represented in DE 32 42 901 A1. The employed counter-flow principle is advantageous and essential for the arrangement of the air baffle plates according to the invention, as a result of which a substantially homogeneous temperature stratification of the cooled battery cells is achieved. The counter-flow

principle requires that the heated air is also discharged at the side where the cold air is fed in. The arrangement of the air baffle plates 11, which is shown in the present drawing, furthermore provides the advantage that, by increasing the active cooling surface area along the air path through the cooling-body element 7, the local removal of cooling power because of the heating of the air along the path is substantially compensated. A substantially homogeneous cooling power is thereby achieved over the entire effective cooling surface area of the cooling-body element 7.

Figure 2b now shows, as a complement to Figure 2a, the outlet filter 14 which discharges the heated cold air outwards via the air outlet connecting element 4. The outlet funnel 14 has the same advantageous features as the inlet funnel 8 which was represented in Figure 2a but has been omitted in Figure 2b for the sake of clarity. By virtue of the particular design of the funnels 8 and 14, the air stream is, as already mentioned, optimized and the occurring pressure loss is minimized. The two funnels 8 and 14 are arranged offset in the breadth direction, in order to exploit the overall space optimally. The air leaving the cooling-body elements 7 via the outlet openings 10 is first fed into an outlet chamber 13 before it is discharged via the outlet funnel 14. Since the heated air flowing out in the lower region of the outlet opening 10 flows, after diversion upwards, past the cold air flowing in via the inlet opening 9, thermal insulation, for example in the form of a thin air cushion, may advantageously be provided between the two arrangements which guide the air.

The air guidance through the cooling body 6 according to the invention is represented in summary hereinbelow with the aid of the two figures 2a and 2b: the cold air enters the inlet funnel 8 via the air inlet connecting element 3. After diversion at the end of the funnel 8, the air flows through the corresponding inlet opening 9 into the respective cooling-body element 7. At the

end of the air duct 12, which acts as a diffuser, the air flows back in counterflow in the upper and lower region of the cooling-body element. The air leaves the cooling-body elements 7 via the outlet openings 10 and is then fed into the outlet chamber 13, diverted at the upper end of the latter and collected in the outlet funnel 14. The air is discharged via the air outlet connecting element 4.

Figure 3 shows an alternative embodiment for a cooling-body element 7′, in which the counterflow principle is used in the reverse direction. An outlet opening 10′ is here arranged centrally and two inlet openings 9′ are arranged above and below. Correspondingly, the air baffle plates 11′ are also arranged differently, namely such that an air duct 12′ which widens in the through-flow direction again results. Naturally, in the case of both embodiments of the cooling-body element 7′, the supply and discharge air feed paths must be matched.

When using the technical teachings set out, other developments for the cooling-body elements 7 are also conceivable, without further instruction, for example with a plurality of inlet and outlet openings. Furthermore, the same, or a similar, parallel arrangement of the cooling-body elements may also be derived for through-flow of the coolant in the transverse direction (y direction) and in the height direction (z direction) of the battery cells.

The cooling-body elements may, as described, be realized in a closed design or, alternatively, may be directly bounded by the lateral faces of the battery cells (open design), in which case it is necessary to adhere to a corresponding electrical insulation.

An alternative coolant, for example oil, may also equivalently flow through the cooling body instead of air.

Claims

1. A high-temperature battery for the power supply of electrically powered vehicles, having a thermally insulating housing and a cooling system with a cooling body which is arranged inside the housing, and through which a coolant flows, which
- penetrates the thermally insulating wall of the housing by means of inlet and outlet connecting elements, and
- is formed by a parallel arrangement of plate-shaped cooling-body elements comprising hollow bodies and through which the coolant flows, the battery cells to be cooled being arranged in the space between the parallel cooling body elements, wherein
each cooling body element has, on a narrow side facing the inlet and outlet connecting elements, at least one inlet opening and at least one outlet opening, an inlet funnel or funnels which widen(s) downstream in the breadth direction, distributing the coolant over the inlet openings of all the cooling-body elements and an outlet funnel or funnels which narrow(s) downstream in the breadth direction collecting the coolant flowing out of the outlet openings of all the cooling-body elements and feeding it to the outlet connecting element.

2. A high temperature battery according to Claim 1, wherein the battery cells are in the shape of a bar, and at least one of the long lateral faces of each cell is in thermal contact with a cooling-body element.

3. A high temperature battery according to Claim 1, wherein the inlet funnel and the outlet funnel are formed perpendicularly to the breadth direction such that when the coolant flow passes through the funnels the respective instantaneously crossed cross-sectional area remains substantially unaltered.

4. A high temperature battery according to Claim 1, wherein baffle plates are arranged inside each cooling-body element, which baffle plates distribute inside the cooling-body element the coolant flowing in through one or more inlet openings and support diversion of the coolant flow to one or more outlet openings.

5. A high temperature battery according to Claim 4, wherein the cross-sectional area crossed by the coolant on inlet into a cooling-body element is smaller than the cross-sectional area crossed on outlet.

6. A high temperature battery according to Claim 5, wherein the baffle plates form a coolant duct which widens in the throughflow direction.

7. A high temperature battery according to Claim 5 or 6, wherein, on passage through the cooling-body element, the cross-sectional area instantaneously crossed in each case by the coolant flow monotonically increases.

8. A high temperature battery according to Claim 1 or 5, wherein each cooling-body element has an inlet opening arranged in a central position and two outwardly arranged outlet openings.

9. A high temperature battery according to Claim 1 or 5, wherein each cooling-body element has an outlet opening arranged in a central position and two outwardly arranged inlet openings.

10. A high temperature battery according to Claim 1, wherein either a coolant gas or a coolant liquid is used as the coolant.

11. A high-temperature battery for the power supply of electrically powered vehicles, substantially as described herein with reference to and as illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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GB 9510874.2

Relevant Technical Fields

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(ii) Int Cl (Ed.) H01M 10/50; 6/50

Search Examiner
M J INSLEY

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28 JULY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE: WPI

Documents considered relevant following a search in respect of Claims :-
1-11

Categories of documents

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2269476 A (VARTA) see whole document	
A	US 4578324 A (FORD AEROSPACE) see whole document	
A	US 4517263 A (BROWN BOVERI) see whole document equivalent to DE 3242901 referred to	
A	WPI Abstract Accession No. 95-156342/21 & DE 4408968 see the abstract	
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